AFRL-RX-TY-TP-2009-4569

FUEL REFORMING TECHNOLOGIES
(BRIEFING SLIDES)

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SEPTEMBER 2009

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14. ABSTRACT

The AFRL/RXQD Energy program demonstrates current technologies in solar power generation and the integration of these technologies onto deployed base structures. This presentation is to describe those efforts along with the capabilities and competencies that have come as a result of this program.

15. SUBJECT TERMS

JP-8, fuel reforming, solid oxide fuel cell, catalysis

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Fuel Reforming Technologies

Deployed Energy & Utility Systems – Overview

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Mission

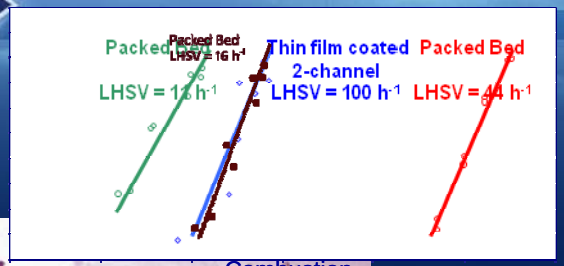
Conduct Exploratory, Advanced, and Applied Research To Develop Next Generation Deployed Energy and Utility Systems To Meet New and Evolving Warfighter Needs

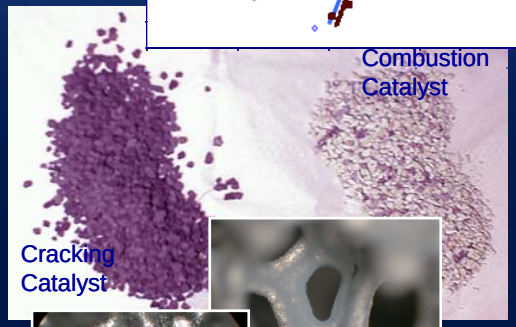
Benefit To The Warfighter

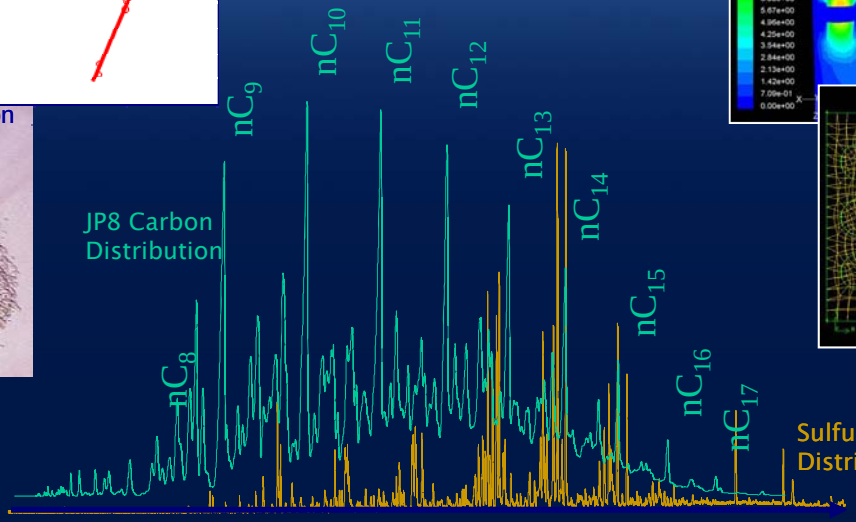
- Reduce Deployed Footprint While Enhancing Operational Efficiencies And Maintenance Requirements
- 50% Reduction In Power Deployment Airlift
- 82% Reduction In Fuel Consumption
- Reduce / Eliminate External Fuel Requirements, Saves Lives Of Soldiers, Marines, Sailors, and Airmen

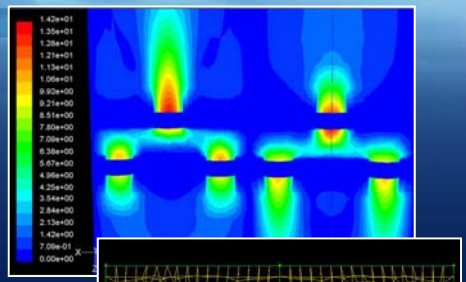
Tech Development

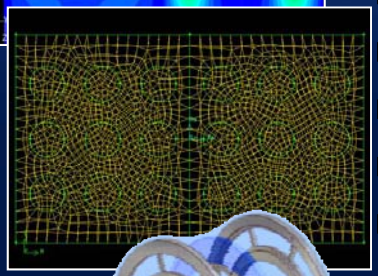
$$\text{Conversion}\ (wt\ .\%) = 100\left(1 - \frac{m_{Liquid}}{Q_{Feed}\ \Delta td^{JP-8}}\right) \qquad LHSV\ (h^{-1}) = \frac{60\,Q_{Feed}}{V_{Reactor}}$$

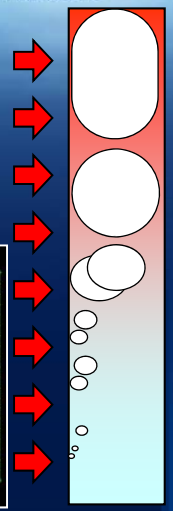


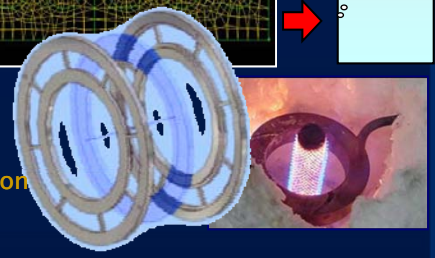










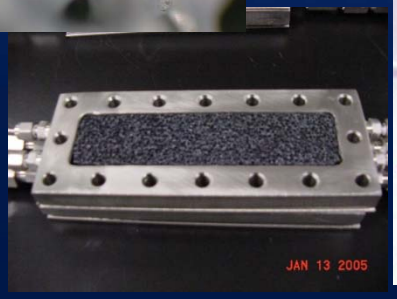


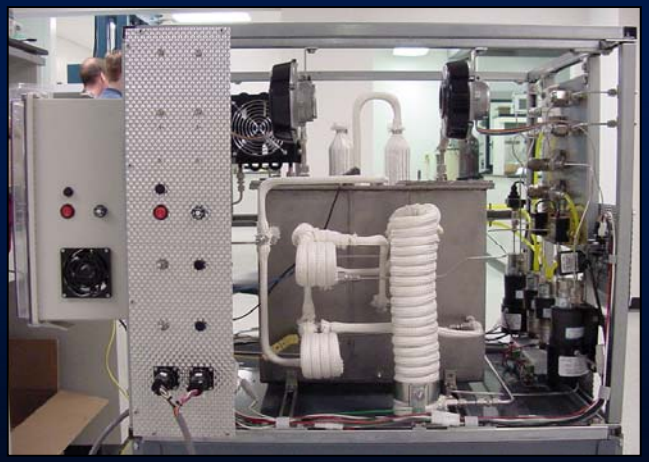
The Objectives: Develop The Underlying Concepts in Advanced Heat and Mass Transfer, Catalysis and Surface Chemistry, and Energy Conversion For an Efficient and Compact Energy System

The Technical Approach: Applying Transport Phenomena Theories, Formulation, and Modeling; Computational and Experimental Fluid Dynamics; Catalyst Kinetics Modeling, Catalyst Chemistry and Surface Analysis, Reactions Thermodynamics Modeling, Novel Catalyst Materials Formulation, and Catalyst Coating On Substrate; Catalytic Reactor system Testing and Analysis; Synthesis of Panchromatic Sensitizers; And Experimentation and Analysis

To Accomplish These Goals: In-House and Contracted Research to Universities and Industry, Leveraging and Collaborating with National Laboratories and DoD Services

Multi-fuel Reformer





Objective

Develop Reformer System Capable Of Converting Liquid Fuels Into Hydrogen For More Efficient Use In Fuel Cell Stacks

Technology Challenges

- Novel catalyst materials formulation
- Catalytic reactor system testing and analysis
- Catalyst Coating On Metal Substrate
- Reactions Thermodynamics Modeling
- Process water recovery

Benefits to the Warfighter

- To Reduce Deployed Energy Systems Footprint While Enhancing Operational Efficiencies And Maintenance Requirements
- To Achieve 60% Reduction In Power Deployment Airlift *(from 4 Sorties down to less than 2 Sorties)*
- To Save 3400 Gallons Of Fuel/Day/1100men Deployment
- To Reduce Noise/Thermal Signature And Environmental Emissions

Advanced Heat and Mass Transfer

Advanced Heat and Mass & Transfer Technologies

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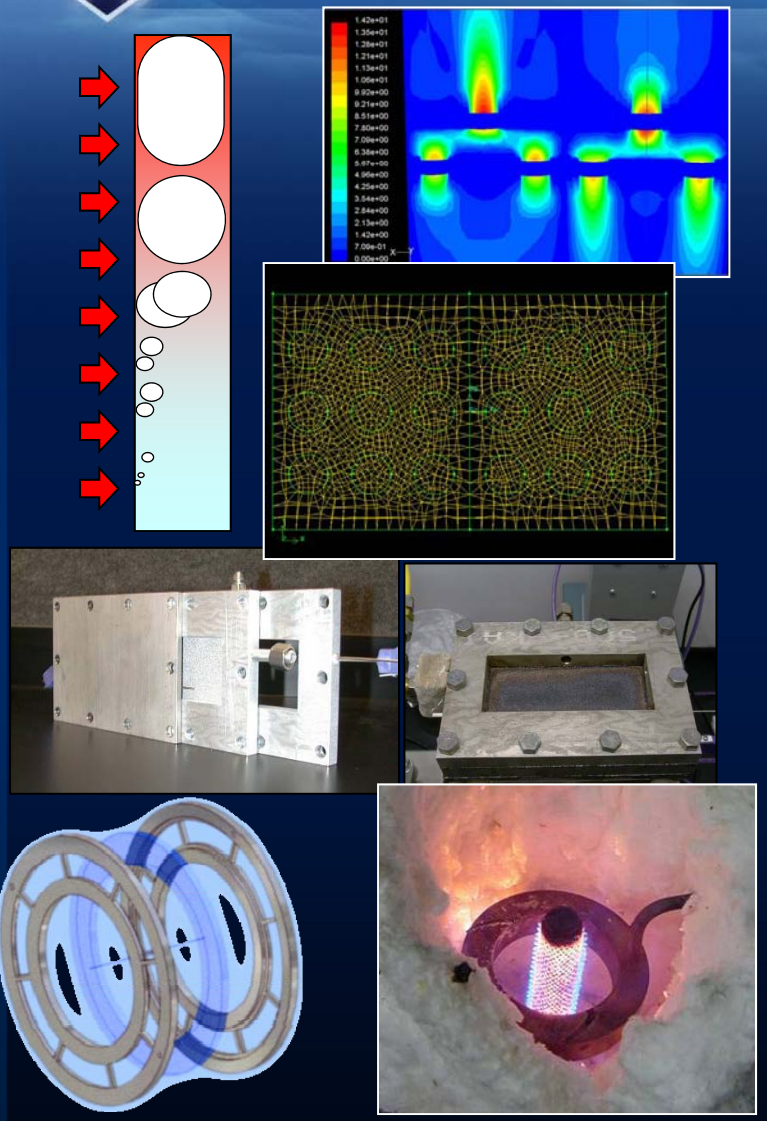


Objective

Identify And Develop New Technologies To Enhance Heat And Mass Transfer In Deployed Energy Systems

Technology & Core Competency

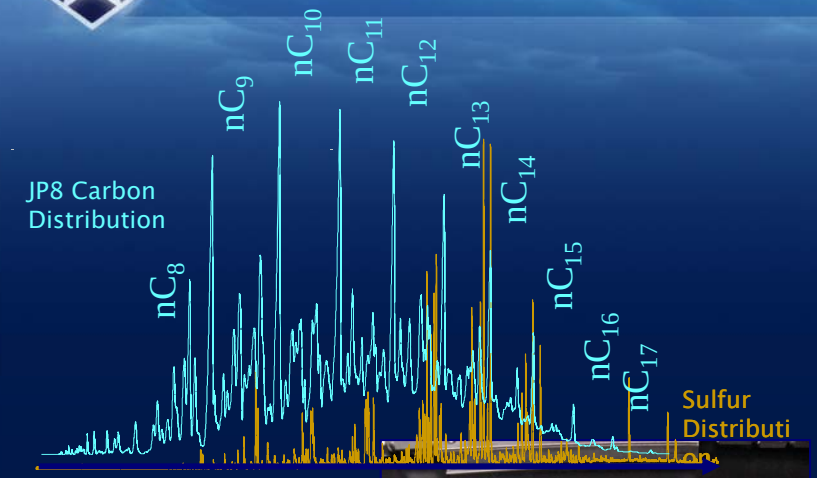
- Microchannel and Matrix Technologies
- Transport Phenomena Theory, Formulation, And Modeling
- Computational And Experimental Fluid Dynamics
- Mechanical Design And Instrumentation
- Laboratory Experimentation And Analysis
- Collaboration With Academia And Industry

Benefits to the War Fighter

- Reduce Deployed Footprint While Enhancing Operational Efficiencies And Maintenance Requirements
- 50% Reduction In Power Deployment Airlift *(From 4 Sorties Down To Less Than 2 Sorties Of C-130 Per 1100 Men)*
- Increase In MTBF From 500 Hrs To 2200 Hrs.
- Savings Of 1800 Gallons Of Fuel/Day/1100 Man

Catalysis Technologies

Catalysis Technologies



Objective

Develop New Catalysis Technologies For Process Intensification To Enhance Performance of Deployed Energy Systems

Technology & Core Competency

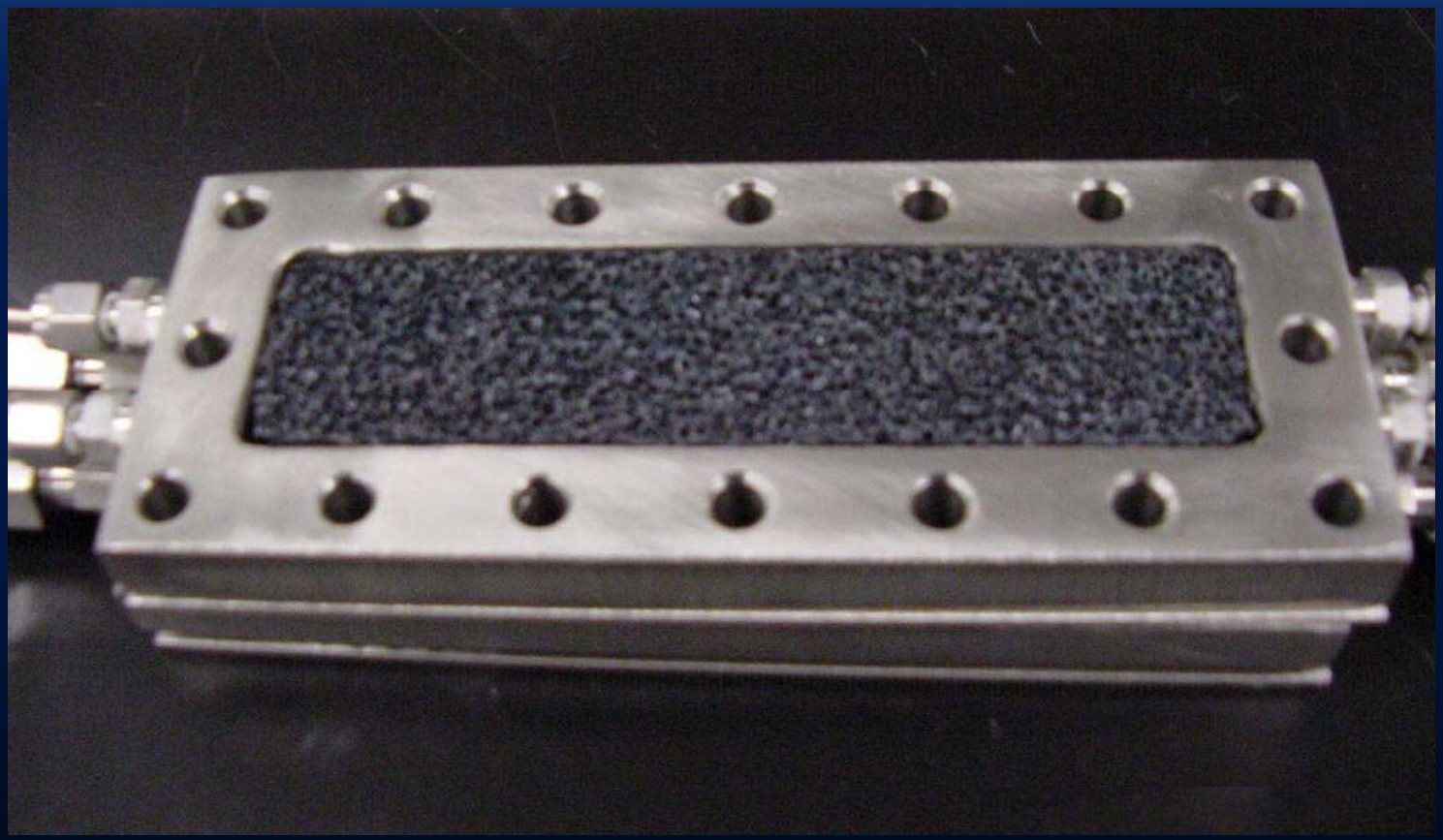
- Catalyst Kinetics Modeling and Testing
- Catalyst Chemistry and Screening
- Surface Analysis and Chemistry
- Reactions Thermodynamics Modeling
- Novel Catalyst Materials Formulation
- Catalyst Coating On Metal Substrate
- Catalytic Reactor system Testing and Analysis

Benefits to the War Fighter

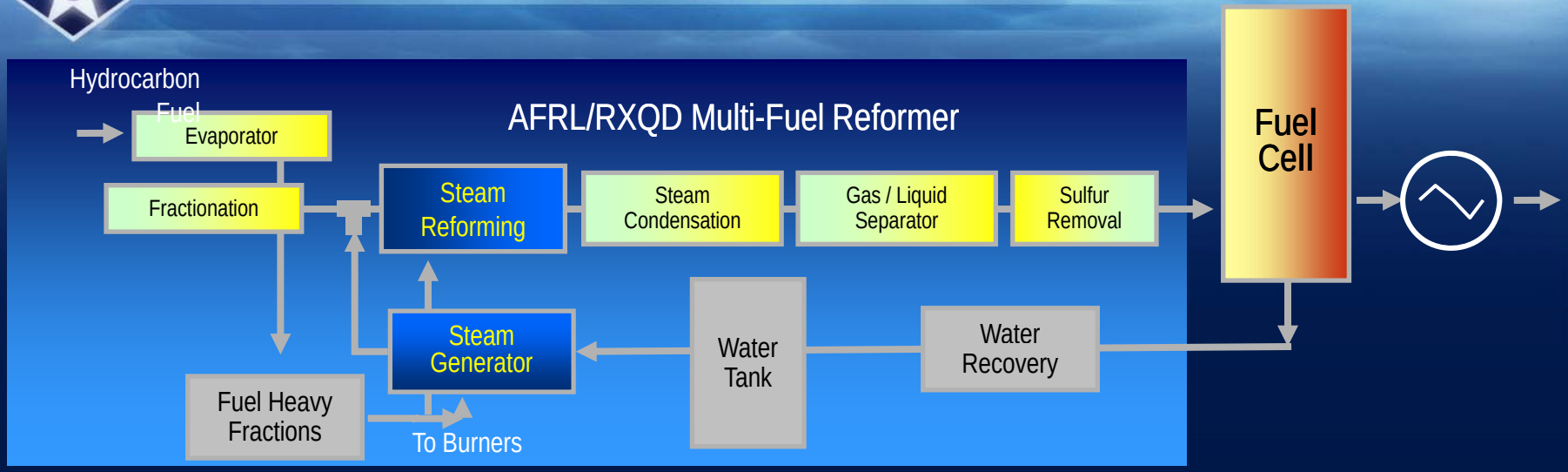
- 50% Reduction in Power Deployment Airlift *(from 4 Sorties down to less than 2 Sorties of C-131 per 1100 men)*
- Increase in MTBF from 500 hrs to 2200 hrs.
- Savings of 1800 gallons of fuel/day/1100man deployment (5,280 Gal. vs. 3,480 Gal.)
- Reduced Noise Signature (70 db vs. 120 db)

Process Intensification Impact

Reduced Steam Reformer Size By 10 Folds



Preliminary Test Results Comparison



The preliminary test results confirmed the benefits of using FT-Petroleum 50/50 mix over Petroleum JP-8:

- Due to the reduction in aromatics and sulfur contents, the mix test runs were conducted without the use of fractionation. This has the potential to eliminate the fractionation component and reduce the size of the sulfur removal component by 50%--less maintenance.
- The mixed blend behaved similarly to Petroleum JP-8, however, it burned cleaner and processed fuel at much lower temperatures without producing non-condensable aerosol.
- Achieved complete conversion with less CO_2 and no higher hydrocarbons than methane was detected. Methane and CO along with H_2 are fuels for the Solid Oxide Fuel Cell (SOFC).

Preliminary Test Results Comparison

Test Runs	H_2	CO	CH_4	CO_2	C_2H_4	C_2H_6	C_3H_6	Steam Reformer Exit Temp
	[mol%]	[mol%]	[mol%]	[mol%]	[mol%]	[mol%]	[mol%]	[C]
Petroleum JP-8								
1	**75.2 %**	12%	**0%**	**12.8%**	0%	0%	0%	**800**
2	**72.4 %**	11.9%	**3.8%**	**11.8%**	0%	0%	0%	**716**
50/50 Petroleum JP-8 and FT JP-8 Mix								
1	**75.0 %**	12.4%	**6.3%**	**6.3%**	0%	0%	0%	**640**

Reported Data are the Average of Multiple Test Runs Each

The preliminary test results confirmed the benefits of using FT-Petroleum 50/50 mix over Petroleum JP-8:

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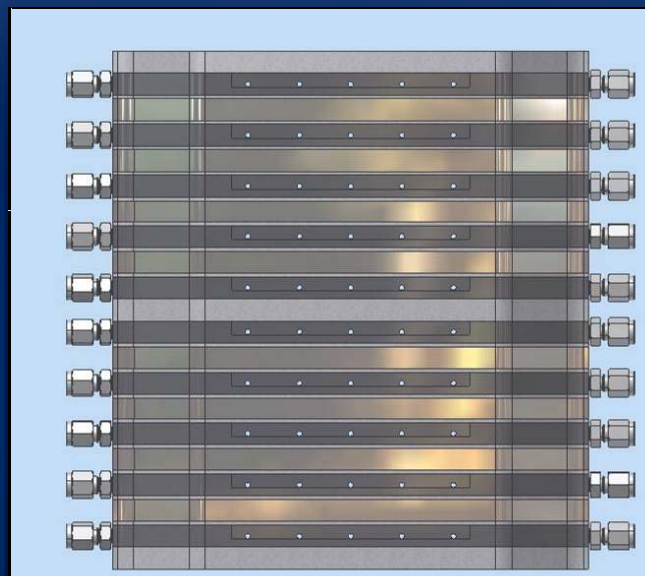
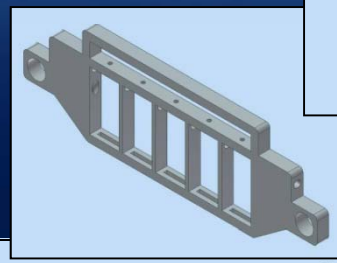
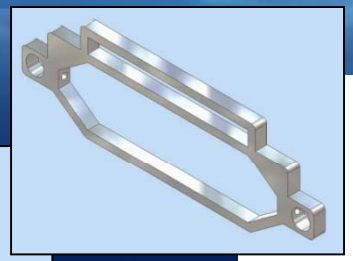
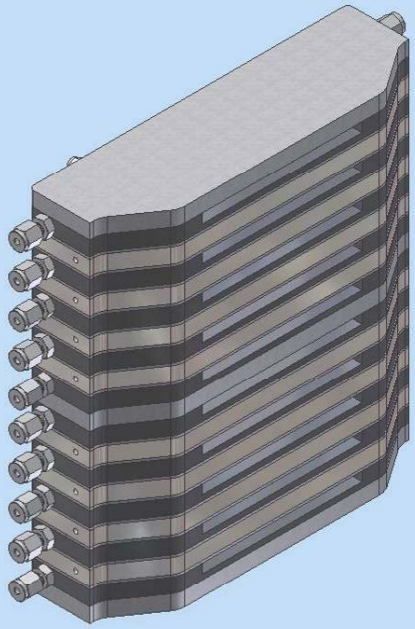
10kWe Lab Demo Unit

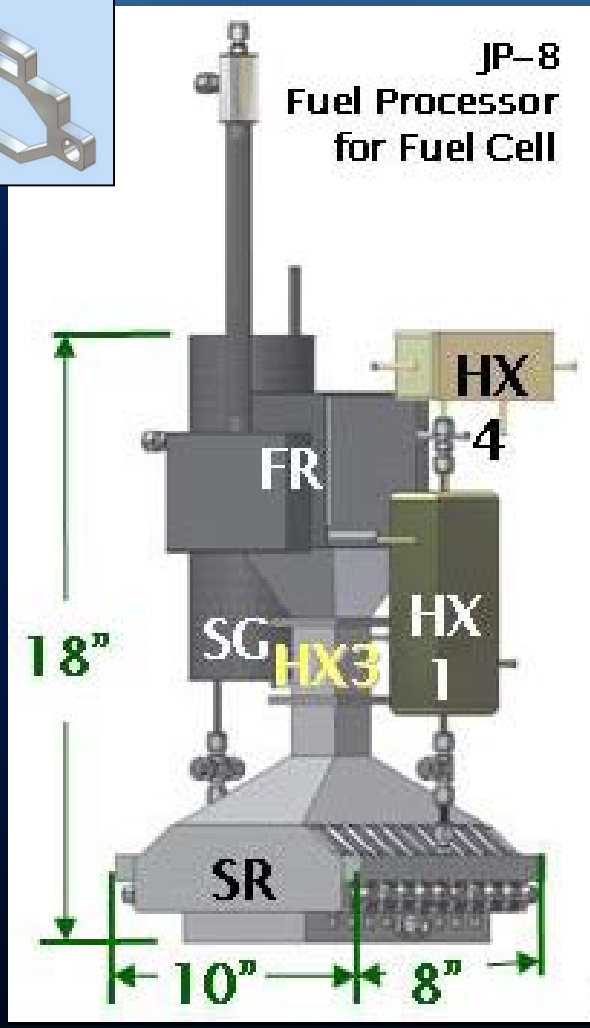


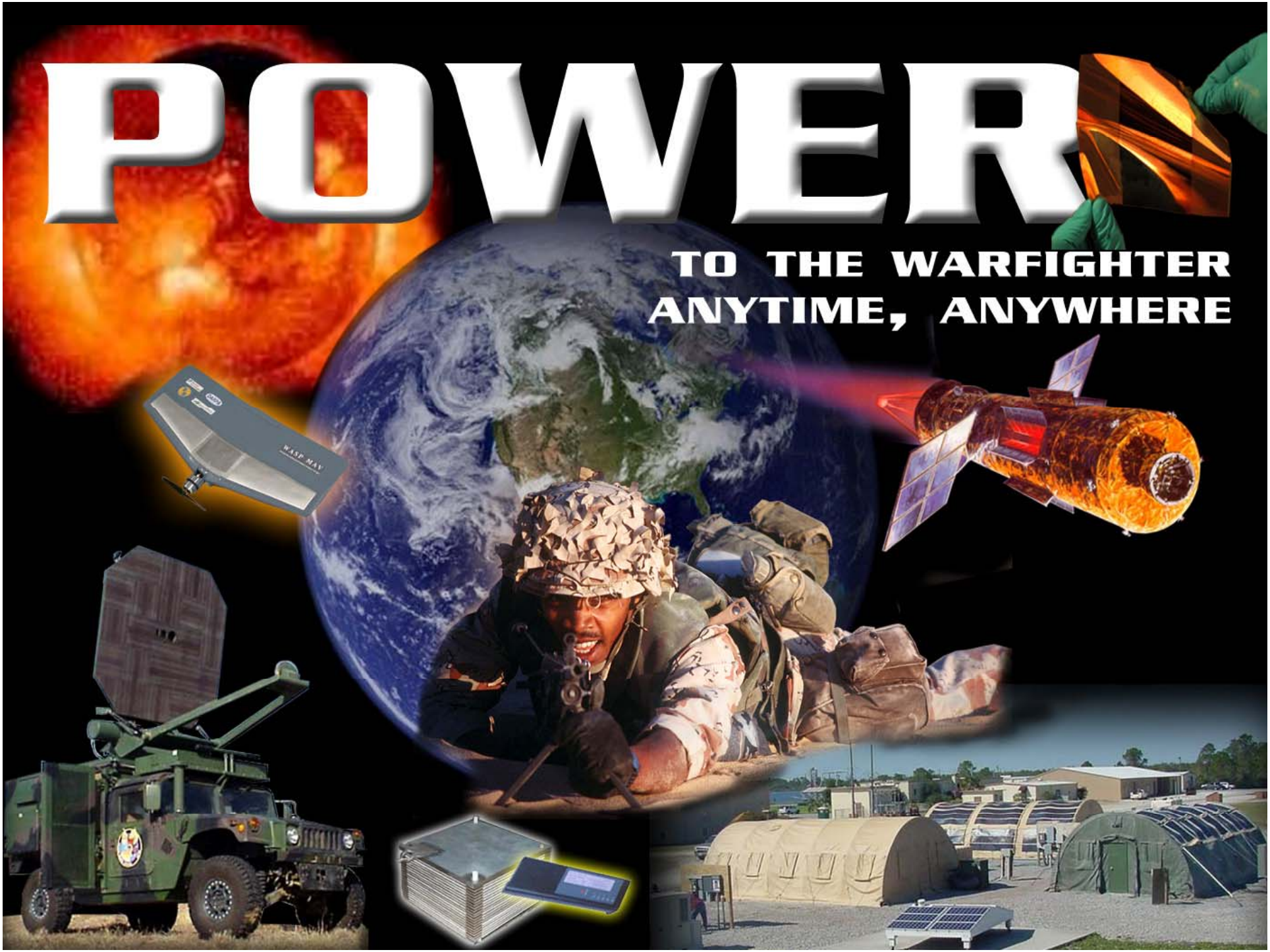






10kWe
Steam Reformer Design




POWER
TO THE WARFIGHTER
ANYTIME, ANYWHERE